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AUDIBLE TRAFFIC SIGNALS - A HELP OR HINDRANCE TO BLIND PEDESTRIANS

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Orientation and mobility (O&M) specialists are the instructors who teach blind persons how to travel independently in the community. Preliminary to understanding the problems related to crossing streets without sight or with severely diminished sight is an understanding of the training procedures used by O&M specialists in teaching street crossings.

There are a number of discrete steps in the process of mastering street crossings. The blind person first walks to the corner, identifies the corner curb, and locates the pedestrian pole and push button. The second step is to become aligned or positioned in such a way as to be facing directly across the street at the desired corner destination. Proper alignment is accomplished by listening to traffic patterns and constructing a "mental map" of the intersection geometry. It should be noted that one of the ways that this mental map is verified is by feeling (with the cane or underfoot) the radius of the curb return.

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The third step, determining when to initiate the crossing, is also accomplished by listening to traffic. The surge of traffic associated with the changing signal phase provides the information of when to step into the street and cross. In order to safely cross and to get to the opposite corner before the pedestrian phase ends, this last step requires both patience and decisive action. Also it requires listening to idling traffic, phase surges, and sorting out left-turn and right-turn traffic so that the actual surge is not misinterpreted. Finally, once in the street the traveler must continue to be alert to turning traffic, idling cars, and at the same time, take care not to veer while walking, especially toward the middle of the intersection.

For some time safety conscious traffic engineers have been experimenting with the use of audible signals designed to remind all pedestrians and not just the visually impaired, when it is a safe time to leave the curb. Audible traffic signals have been in existence for many years but it has only been relatively recently that the technology has advanced in design and become readily available (Hulscher, 1976) Typical features include distinctive sounds for each direction and an internal audiometer that measures ambient sound level and adjusts the audible signal accordingly. The audiometer is sensitive enough to adjust the volume during the traffic surge.

The most commonly used equipment in the U.S. is manufactured by Nagoya Electric Works, Nagoya, Japan and is called the Audio

Pedestrian Signal. North-south and east-west walk directions are distinguished by two different signals that resemble bird calls ("cuckoo" for one direction and "tweet-tweet" for the other direction).

While there have been significant advances in audible traffic signal technology, the basis for determining effectiveness of the devices for blind persons has not advanced beyond anecdotal follow-up reports of individual blind persons and their instructors from experimental test sites. In 1986 blind persons in Southern California volunteered to come to Huntington Beach, California and serve as subjects in a field study of the effectiveness of audible traffic signals. This paper reports the results of that study.

METHOD

The sample of legally blind subjects (N=27) was selected to provide as much diversity as possible in degree of visual impairment, type of assistive devise used (cane, dog, or no aid), and age. All subjects had received some degree of O&M training in street crossing techniques and most were or had been clients of the O&M instructors who drove them to Huntington Beach. They were naive to Huntington Beach but 11 of the 27 had previous experience with audible signals in other communities.

Before the test began, a demonstration of how audible signals worked was given to each subject at an actual intersection.

Then, the subjects were broken up into small groups and taken to each of the four pre-selected intersections. The sequential order of intersections they were taken to was randomized for each group to control for learning effects. The corner of each intersection that each group was brought to was not varied nor was the street that they crossed.

For each subject data were collected on success or failure at finding the pedestrian pole and button, success or failure at crossing, time to cross, and veer while crossing. After crossing the four streets the subjects and the O&M instructors who accompanied them were debriefed in a short follow-up interview.

The Intersections

The four different intersections that were selected for the study represented differing degrees of complexity and presented a variety of challenges to the visually impaired traveller. One intersection ("D") served as a control in that it did not have audible signals.

The geometric configuration of intersection "A" is a 'T' type with a parking lot at the top of the "crossbar" of the 'T'. The street that was crossed has a wide curb return. Each corner has one pedestrian button per pole. The intersection is signalized with audible signals for two through phases for the main and secondary streets. All legs of the intersection have left turn pockets.

An important feature of this intersection is that frequently any one direction will have no traffic, making it difficult to get any auditory sense of the geometry of the intersection and align oneself properly to cross from corner to corner. Additionally, proper auditory alignment is made more difficult by the fact that the one leg of the main street curves horizontally into the intersection. Of the three intersections with audible signals, "A" was the least difficult to cross.

Intersection "B" is a right angle intersection with three lanes in each direction. Curb returns are extremely wide. It is signalized in eight phases with all the left turn pockets being independent phases. Audible signals are used on the four through phases. Each corner has two pedestrian buttons per pole. One button is for pedestrians on foot and the other button is for bicyclists. The width of the streets, the curb returns, and the double button poles are the most challenging aspects of this intersection. Intersection "B" is more difficult to cross than "A" but not as difficult as "C".

Intersection "C" is an oblique intersection with one leg exiting from a shopping center. There are no curbs across the shopping center leg but it is signalized for pedestrians. The main street has three lanes in each direction and four phases -- two left turn phases and two through phases. The secondary streets are also independently phased. The pedestrian poles at the shopping center corner have two buttons per pole, giving the pedestrian the choice of crossing the main or secondary street.

Intersection "C" is an extremely difficult intersection for a blind pedestrian because of it's complexity. It was the most difficult of the four intersections of the study. The light traffic flow of the secondary street into the main street gives very little auditory clue as to the oblique nature of the intersection. The shopping center leg of this intersection with its lack of curbs and intermittent traffic gives the blind traveller the impression of walking across the "crossbar" of a 'T' intersection. In this situation the blind pedestrian can easily pass either of the two shopping center corners without any clue as to the location of the pedestrian pole. The double button poles also add complexity.

Crossing the main street is difficult because the pedestrian crosswalk is a double "dog-leg" with two islands, one at each turning point of the "dog-leg". The first island is a median strip. The second one is a triangular shaped protective island close to the opposing corner. The walking distance from corner to corner is longer than what would be expected when crossing a typical 6 lane, right angle intersection. The added distance from the oblique angle and the double "dog-leg" amounts to approximately one eighth more than a right angle intersection.

The control intersection is intersection "D" -- a right angle intersection with two through lanes in each direction. Each leg has a left turn pocket. The four through phases and the two left turn pockets of the main street are signalized. The pedestrian poles at each corner have one button per pole. The main street has a 14 foot wide median island. The secondary street frequently

has very light traffic, making it difficult for the blind pedestrian to detect the traffic surge of the main street. Of the four intersections, "D" was the least difficult to cross.

RESULTS

For the blind subjects the preliminary step of finding the pedestrian pole was more than a trivial problem (See Table 1). Failures to find the pedestrian pole were most common at intersection "C" where many subjects had a hard time ascertaining the location of the corner due to the lack of a corner curb. Almost all of the difficulties in finding the pole at intersection "C" were of this nature (10 out of 11). Many subjects walked past the corner onto the driveway of the secondary street without realizing that they had passed the corner. Even when a small sub-sample of Subjects (N=5) were told about the lack of a curb at the corner of intersection "C", two out of the five never found the pedestrian pole.

Finding the right pole was more of a problem at intersections "B" and "A", the two intersections with pronounced curb returns. Not surprisingly, a number of subjects at these intersections went directly to the wrong pole and were not able to figure out what had happened and correct the mistake.

TABLE 1. Difficulties Finding The Pedestrian Pole

Intersection	S's Who Never Found Pole	S's Who Went To Wrong Pole	S's Who Went To Wrong Pole Then Corrected Mistake	Intersection Total No.	Difficulty Rate
A	1	2	2	5	18%
B	2	3	3	8	33%
C	9	0	2	11	44%
D	2	0	1	3	12%

[INSERT TABLE 1]

Finding the pole was most difficult for the 5 subjects who used dog guides.

The subjects also had considerable difficulty finding the pedestrian button, especially at "C" (See Table 2.). While those who did not find the pole obviously did not find the button, there were also a few subjects at intersections "B" and "C" who found the pole but never located the button.

The pole at intersection "B" has two buttons on it -- one is the pedestrian button and the other is for bicyclists. Intersection "C" has two buttons on the pole for crossing either the main or secondary street. One subject at "B" and three at "C" found the pole but pushed the wrong button and either never realized that there might be another button or perhaps became disoriented, wondering if they were at the right pole. Four subjects at "C" were able to correct their mistakes by pushing buttons and listening to the signals.

Just as subjects sometimes found the wrong pole at the two intersections with the wide curb returns ("A" and ""B") there was also a problem at these intersections of finding the wrong pole and pushing the wrong button. At "A" two subjects who went to the wrong pole were able to infer that they were at the wrong pole by determining that the button controlled the audible

TABLE 3. The Causes of Failed Attempts To Cross Streets

Intersection	Indecision Regarding Pole/ Button	Initiated Crossing with Opposing Signal	Veered While Crossing	Intersection Total	Failure Rate
A	6	1	1	8	30%
B	6	1	2	7	39%
C	13	0	2	15	75%
D	3	4	0	7	31%

signals in the direction they did not want to go. They then looked for and found the right pole and pushed the right button.

[INSERT TABLE 2]

Many subjects did not succeed in crossing the streets (See Table 3). The failure rates for intersections "A", "B", and D ranged from 30% to 39% and for intersection "C" it was 75%. At the intersections controlled by audible signals (intersections "A", "B", and "C") most failures were related to the problem of finding the right pedestrian pole and button. At these intersections most of the subjects who failed to cross did not step into the street. Five of the seven who did, stepped off the curb at the right time but veered as they walked and had to be stopped for safety reasons. Only one subject at "A" and one at "B" attempted to cross with an opposing signal.

[INSERT TABLE 3]

At the control intersection ("D") the cause of failed crossings differed from the other intersections in one important way. Four out of the seven failures were caused by subjects who stepped into the street and attempted to cross with an opposing signal. For safety reasons the experimenter stopped them from continuing to attempt to cross the street.

At intersection "B", the only eight phase intersection, three of the fifteen subjects crossed with the pedestrian phase from

TABLE 2. Difficulties Finding The Pedestrian Button

Intersection	S's Who Found Pole, But Never Found Button	S's Who Pushed Wrong Button, Then Corrected Mistake: Wrong Pole	S's Who Pushed Wrong Button, Then Corrected Mistake: Right Pole	S's Who Pushed Wrong Button, & DID NOT ~~Then~~ Correct~~ed~~ Mistake	Intersect. Total	Difficulty Rate
A	0	3	0	2	5	18%
B	2	2	1	0	5	20%
C	2	0	3	4	9	36%
D	0	0	0	0	0	0%

across the street. In each of those instances a sighted pedestrian had coincidentally pushed the button to cross the street from the other corner at about the time that the subject had pushed the button. Because of independent phasing, the traffic first surged for the sighted pedestrian (southbound) and then for the subject (northbound). Thus subjects who left with the signal from across the street entered the street approximately 12 seconds early, exposing themselves to eastbound traffic coming from the left turn pocket of the main street.

The analysis of time taken to cross streets (see Table 4) revealed that a majority of subjects arrived at the corner with considerable time to spare but a significant minority took too long to cross. At intersection "C" the one subject who took too long to cross spent 33 seconds "overtime" in the street before getting to the corner. At all other intersections the subjects spent less than 5 seconds "overtime" in the street before getting to the corner.

[INSERT TABLE 4]

The post-test interviews with the subjects and the instructors showed across the board agreement that audible traffic signals are more of a help than a hindrance. The vast majority of both sets of respondents would recommend installation of the equipment in their community but only at intersections that are difficult to cross. The most frequently cited criteria for selecting an appropriate installation site were:

TABLE 4. Time Taken To Cross Streets

Intersection	Length of Ped.Phase (seconds)	Aver. Time of S's Who Crossed (seconds)	Range of Time of S's Who Crossed (seconds)	S's Who Took Too Long	
				N	%Total
A	23	20	11-28	4	22%
B	32	28	19-35	3	25%
C	37	30	12-63	1	12%
D	32	24	16-35	2	13%

- "T" intersection
- Intersections with left turn pockets
- Intersections with right turn arrows
- Intersections where there is periodically light traffic
- Intersections with wide streets
- Intersections with confusing traffic patterns

DISCUSSION

The difficulty that many of the blind subjects had in finding the pedestrian pole serves to highlight the disorientation that can be created by subtle inconsistencies in the architecture of the corner. Without previous exposure to the unusual aspects of the corner such as the extent of the curb returns at intersections "A" and "B" and the lack of a corner curb at intersection "C", it can be expected that many blind pedestrians will not succeed in finding the right pole at those intersections. Verbal information may not be enough -- it was insufficient for two out of the five subjects who were told about the lack of a corner curb at intersection "C".

Subjects who used dog-guides were at a distinct disadvantage when it came to locating the pedestrian pole. When a dog guide user arrives at a corner and is not positioned in the immediate vicinity of the pole, it is difficult to use the dog to explore for it, especially at an expansive corner such as the corner of intersection "B". The dog is trained to avoid obstacles in the path and follow directional commands. It is easier and more efficient to systematically scan a large area for a pole with a

long cane.

Finding the button was almost as much of a problem as finding the pole. In some cases the two problems were interrelated in the respect that a few subjects went to the wrong pole, pushed the wrong button and never corrected the mistake (at "A" and "B"). In other cases subjects were not able to successfully decide between two buttons on a pole (at "B" and"C" the second button was for bicyclists and activates the opposing phase). There were even a few cases of subjects who found the right pole but never found the button on the pole.

A substantial number of subjects who had difficulties finding either the pole or button were able to ascertain that they had made a mistake by listening to the sounds of the traffic and the bird calls. Some were able to properly interpret that information, correct the mistake and go on to make a successful crossing. It should be noted that careful listening and problem solving under the stress of traveling in an unfamiliar, noisy, and potentially dangerous area is not an easy task.

Finding the pole and the button was the major cause of failure to cross the street. It is worth noting that equipment has recently been introduced into the U.S. market which features a continuous audio "locating signal" (a "tap-tap" sound) emitted from the pedestrian button during the "Don't Walk" condition (Aldridge Traffic Systems, Melbourne, Australia). The device provides a tactile signal on the push button assembly (from a vibrating

diaphragm) designed to help in identifying the "Walk" indication. The push button is large (approximately 3" in diameter) and has a long travel distance (approximately 1/2") which, when taken together, easily distinguish it from a bicyclist pedestrian button.

Attempting to cross with an opposing signal was by far the most dangerous mistake that the subjects could have made. When a pedestrian suddenly steps into surging traffic the driver of a vehicle is given almost no warning and very little stopping - distance. The data on failures to cross due to attempting to cross with an opposing signal showed that this danger was most pronounced at the control intersection ("D"), the intersection that was the easiest to cross. Subjects had difficulty identifying the correct traffic surge.

However it is important to note there were two attempts to cross at the wrong time at intersections other than "D" -- once at intersection "A" and once at "B". Thus the audible signals were not always helpful in providing the necessary verification to cross at the right time. Clearly the pedestrian must take the time to carefully cross-verify signal information with traffic sounds, a process which can be time consuming and fatiguing.

Additionally it must be recognized that the tendency to cross with the pedestrian phase from across the street (at an 8 phase intersection such as "B") is a serious limitation of audible signal technology. It can only be overcome by carefully

listening to the volume of both signals and only crossing with the louder one.

There was no evidence to suggest that veering tendencies or overtime crossings were influenced by the audible signals. Considering the street width and intersection geometry of intersections "A", "B", and "C", it is surprising that there were not more than 5 instances of veering and 8 instances of taking too long to cross.

CONCLUSION

Clearly, subjects were exposed to increased risk at the control intersection ("D") as they had a higher rate of crossing with the opposing signal. The intersections with audible signals were more complex than "D" yet subjects were exposed to less risk -- there were fewer instances of crossing with the opposing signal. Thus it is logical to assume that installing audible signals at "D" would reduce risk. However, while this study documented that audible signals aid the blind pedestrian in crossing complex streets, it also served to point out the limitations associated with audible signal technology.

At complex intersections where audible signals offer the prospect of increased pedestrian safety, blind pedestrians have difficulty locating the proper pedestrian pole and push button. While there may be very little flexibility in re-designing corners, traffic

engineers should recognize that finding the pole and button may be a serious problem for some blind pedestrians. Whenever possible design solutions should be implemented (i.e, one button per pole).

Also, although they provide an extra measure of safety, audible signals have an inherent drawback. At complex intersections where it is to difficult to cross, audible signals require additional listening tasks which, in turn, add to the difficulty of crossing the street. The key to overcoming this drawback is pedestrian education and training. For the blind pedestrian, the full advantage of audible signals can only be realized with instruction and practice in their use.

REFERENCES

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